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(71) Applicant : **SANDEN CORPORATION**
20 Kotobuki-cho
Isesaki-shi Gunma, 372 (JP)

(72) Inventor : **Yokoyama, Hiroyuki, c/o Sanden Corporation**
20 Kotobuki-cho
Isesaki-shi, Gunma 372 (JP)

(74) Representative : **Jackson, Peter Arthur**
GILL JENNINGS & EVERY, Broadgate House,
7 Eldon Street
London EC2M 7LH (GB)

(54) Scroll type compressor with variable displacement mechanism.

(57) A variable displacement type scroll compressor is disclosed. The compressor includes a housing having fluid inlet and fluid outlet ports. A fixed scroll is fixed within the housing and includes a first circular end plate from which a first spiral element extends. An orbiting scroll includes a second circular end plate from which a second spiral element extends. A pair of holes are formed through said first circular end plate of the fixed scroll. A pair of bypass passages communicate the corresponding intermediately located fluid pockets with the suction chamber. A pair of cylinders corresponding the pair of bypass passages are formed within the bypass passages. A valve member having a first axial end and a second axial end is slidably disposed within each of the cylinders so as to close and open the corresponding bypass passage. A bias spring is disposed within the cylinder so as to urge the valve member to close the bypass passage The cylinder is located so as to let the valve member receive pressure in the intermediately located sealed-off fluid pocket at the first axial end thereof. An electromagnetic three-way valve selectively controls a communication between the suction chamber and a cavity defined by the second axial end of the valve member and the cylinder, and a communication between the discharge chamber and the cavity.

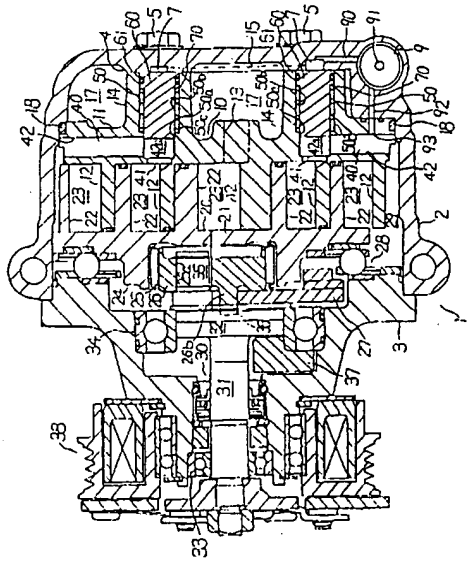

FIG. 2

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The invention relates to a scroll type compressor, and more particularly, to a scroll type compressor with a variable displacement mechanism.

A scroll type compressor which can vary the compression ratio is well known in the art.

In the scroll type compressor with a variable displacement mechanism is illustrated in Figures 1(a) and (b). A variable displacement mechanism is similar to the variable displacement mechanism described in Japanese Utility Model Application Publication No.63-177688. Bypass passage 40 is formed of bypass hole 41 formed in first plate 11 of fixed scroll member 10, and side bypass passage 42 which is formed in first plate 11 and extends in a radial direction of first plate 11. Cylinder 50 is coaxial with side bypass passage 42, and thus shuttle valve 60 is coaxial with side bypass passage 42. Spring 70 biasing shuttle valve 60 is disposed in side bypass passage 42.

The pressure in cylinder 50 is controlled adjust a pressure applied against the rear surface of shuttle valve 60. The position of shuttle valve 60 is controlled for opening and closing bypass passage 40, utilizing a force relation ship between the adjusted pressure and the force of spring 70 biasing shuttle valve 60.

For this purpose, the compressor in the prior art is provided with discharge pressure passage 103 for introducing fluid in the discharge chamber into the cylinder 50,and is also provided with suction pressure passage 104 for returning the fluid in the cylinder 50 to suction chamber. Orifice 105 is provided in discharge pressure passage 103 so that a reduced discharge pressure is always introduced into cylinder 50.

Meanwhile,the device for controlling the pressure between suction pressure passage 104 and discharge pressure passage 103 is obviously provided in suction pressure passage 104.(not shown) Above device selectively opens and closes suction chamber passage 104 to adjust the pressure.

Therefore, the force applied to the opposite end surface of the shuttle valve have a relationship expressed as follows.

When suction chamber passage 104 is opened, and changing a displacement of the compressor from the maximum value to the minimum value, the end of cylinder 50 near suction pressure passage 104 is brought into communication with suction chamber, so that the fluid gas in cylinder 50 immediately flows through suction pressure passage 104 into suction chamber. Assuming that the control pressure introduced into the cylinder 50 is Pc, the pressure of the gas being compressed in fluid pocket located at a position allowing communicating with bypass hole 41 is Pm, the discharge pressure is Pd, the suction pressure is Ps and the spring force of spring 70 is F, force P caused by the difference between the forces applied to the opposite end surface of the shuttle valve 60 is expressed as follows.

$$P = Pc - Ps + F$$

Consequently, a relationship of Pc = Ps is established, and thus only spring force F acts as the force for opening shuttle valve 60, resulting in a problem relating to the responsibility of shuttle valve 60 in cylinder 50.

According to these structures, when shuttle valve opens bypass passage, the fluid gas which is compressed in the fluid pocket immediately returns through bypass passage into suction chamber 29. Therefore, when shuttle valve 60 opens bypass passage 40, the fluid gas which is compressed and passes over one end surface of shuttle valve 60, immediately flows through bypass passage 40 into suction chamber 29, so that the end of shuttle valve 60 hardly receives the pressure of the fluid gas being compressed.

Further,Spring 70 causes a pressure loss when the fluid gas flows through bypass passage 40 in to suction chamber since spring 70 for biasing shuttle 60 opened is disposed in bypass passage 40.

It is an object of the invention to provide a variable displacement scroll type compressor which has a superior responsibility relating to the displacement control of the compressor.

It is another object of the present invention to provide a variable displacement scroll compressor which can precisely obtain the minimum displacement.

According the present invention, a variable displacement scroll type compressor including a housing having a fluid suction port and a fluid discharge port, a fixed scroll member having a first circular end plate and a first spiral element extending from one end of said first circular end plate, a discharge hole formed at a central portion of said first circular end plate, said fixed scroll member fixedly disposed in said housing, an orbiting scroll member having a second circular end plate and a second spiral element which extends from one end of said second circular end plate, a driving mechanism to effect the orbital motion of said orbiting scroll member, and a rotation-preventing mechanism for preventing the rotation of said orbiting scroll member during its orbital motion whereby the volume of the sealed-off fluid pockets change, a suction chamber formed between an outer peripheral surface of said fixed scroll member and said orbiting scroll member and an inner peripheral surface of said housing, and being communicated with said fluid suction port, a discharge chamber communicated with said discharge hole and said fluid discharge port, at least one bypass passage communicating at least one corresponding intermediately located fluid pocket with said suction chamber, at least one cylinder corresponding to said at least one bypass passage formed within said at least one bypass passage, at least one valve member corresponding at least one said bypass passage having a first axial end and a second axial end slidably disposed within said at least one corresponding cylinder so as to close and open said

at least one bypass passage, and an elastic member biasing said at least one corrresponding valve member to urge said at least one valve member so as to close said at least one bypass passage, the improved comprising:

said at least one cylinder located so as to let said at least one valve member receive pressure in said at least one intermediately located sealed-off fluid pocket at said first axial end thereof, communication control means for selectively controlling a communication between said suction chamber and a cavity defined by said second axial end of said valve member and said at least one cylinder, and a communication between said discharge chamber and said cavity.

In the accompanying drawings:-

Figure 1 is a cross sectional view of a principal part of a first example of the variable displacement scroll compressor in the prior art, Figure 1(a) shows a open state of the bypass passage and Figure 1(b) is a closed state of the bypass passage.

Figure 2 is a vertical cross-sectional view of a scroll type compressor with a variable displacement mechanism in accordance with one embodiment of this invention.

Figure 3 is an elevation of a cup-shaped casing of the variable displacement scroll compressor shown in Figure 2.

Figure 4 is an elevation of a fixed scroll member of the variable displacement scroll compressor shown in Figure 2.

Figure 5 is a rear view of a fixed scroll member of the variable displacement scroll compressor shown in Figure 2.

Figure 6 is a view of the relationship between front and rear sides of the fixed scroll member shown in Figure 4 and 5.

Figure 7 is a view of the relationship between a front side of the cup-shaped casing shown in Figure 3 and A rear side of the fixed scroll member shown in Figure 5.

Figure 8 is a cross sectional view of a principal part of the variable displacement scroll compressor shown in figure 2, Figure 8(a) shows a closed state of the bypass passage and Figure 8(b) is an enlarged view of an electromagnetic valve In Figure 8(a).

Figure 9 is a cross sectional view of a principal port of the variable displacement scroll compressor shown In figure 2, Figure 9(a) shows a open state of the bypass passage and Figure 9(b) is an enlarged view of an electromagnetic valve in Figure 9(a)

Referring to Figure 2 and 3, housing 1 is formed of cup-shaped casing 2 and funnel-shaped front end plate 3 which closes an open end of cup-shaped casing 2. Cup-shaped casing 2 is provided with a fluid port (not shown) for introducing fluid into housing 1, and fluid discharge port (not shown) for externally discharging the fluid in the housing 1. Cup-shaped casing 2 is provided at an inner surface of its one end with a nearly annular rib 4 having a portion 4 lower than the other portion. Rib 4 is provided with four apertures 6 through which bolts 5 are inserted. Control pressure passage 7 and groove 8 connecting control pressure 7 are formed in an upper surface of rib 4. Cup-shaped 2 is provided at its one end with an electromagnetic valve accommodation chamber 9 for accommodating three way electromagnetic valve 80, which will be described later.

Referring to Figure 3,4,5, orbiting scroll member 10 has first plate 11 of a nearly circular shape, and first spiral member 12 formed on surface of plate 11. First plate 11 is provided at its central portion with discharge 13 and also at other surface with C-shaped rib 14 surrounding discharge port 13. Rib 14 has a shape corresponding to that of rib 4 of cup-shaped casing 2, and has an end surface which is in contact with rib 4. Therefore, groove 8 formed in rib 4 is covered with end surface of rib 14 to form communication passage 15 connecting control pressure passage 7.

As a result, the pressure in the two control pressure passage 7 are equal to each other. Rib 14 is provided with female threads 16, which engage with bolts 5 inserted through insertion aperture 6 from an outside of housing 1. Thereby, fixed scroll member 10 is fixedly disposed in housing 1, and discharge chamber 17 is formed between first plate 11 and the end of cup-shaped 2. Discharge chamber 17 is in communication with discharge port 13 and the fluid outlet port. Seal member 18 for maintaining air tightness of discharge chamber 17 is provided between the outer peripheral surface of first plate 11 and inner peripheral surface of cup-shaped casing 2.

Orbiting scroll member 20 has second plate 21 of a nearly circular shape, and second spiral member 22 formed on one surface of second plate 21. Orbiting scroll member 20 is assembled with fixed scroll member 10 so that second spiral member 22 is engaged with first scroll member 12 with phase deviation of 180 degrees. This forms a plurality of fluid pockets 23 between fixed scroll member 10 and orbiting scroll member 20. Second plate 21 is provided at the other surface with boss 24. Bushing 26 is disposed inside boss 24 with needle bearing 25 therebetween. Bushing 26 has an eccentric aperture 26a and a pin 26b. Bushing 26 is provided with counter weight 27 or canceling a centrifugal force by orbiting scroll member 20. Rotation preventing thrust bearing mechanism 28 is disposed between second plate 21 and front end plate 3, and prevents the rotation of orbiting scroll member 20 on its axis during revolution thereof along a circular path. Fixed scroll member 20 and orbiting scroll member 10 assembled together form a space, i.e., suction chamber 29 between the inner peripheral surface of the cup-shaped casing 2 and the outer peripheral surfaces of fixed scroll member 10 and orbiting scroll member 20. Suction chamber 29 is in com-

munication with the fluid inlet port.

Drive shaft 30 is has small diameter portion 31 and large diameter portion 32 provided at one end of portion 31. Small diameter portion 31 is rotatably supported by ball bearing 33 disposed inside one end of the front end plate 3. The large diameter portion 32 is rotatably supported by a ball bearing 34 disposed inside the other end of the front end plate 3, and 32 is provided at an eccentric position with crank pin 35, which is inserted into eccentric aperture 26a in bushing 26. Thereby, drive shaft 30 and orbiting scroll member 20 are connected together, so that orbiting scroll member 20 moves along the circular path in accordance with the rotation of drive shaft 30 large diameter portion 32 is also provided with arc-shaped groove 16 for receiving pin 26b of bushing 26. The arc of groove 26 has a center coincident with the center line of crank pin 35. Owing to the engaging of the groove 36 and pin 26b, the rotation of bushing 25 around crank pin 35 is restricted. Counter weight 27 for canceling a centrifugal force by the movable scroll member 29 is attached to drive shaft 30. The end of drive shaft 30 is connected to electromagnetic clutch 38 equipped around the end of front end plate 3.

Also referring to Figure 5, bypass passages 40 communicating the fluid pockets 23 with suction chamber 29 are formed of bypass hole 41 formed in first plate 11 and side bypass passage 42 communicating with bypass hole 41. Each bypass hole 41 is parallel to an axis of drive shaft 30 (will be merely referred to as "axis"). Bypass hole 41 are located so that a pair of fluid pockets 23 communicate with them when those pockets 23 reach the central portions of first and second spiral members 12 and 22. Side bypass passage 42 extends in the radial direction of first plate 11, and each have one end 42a configured to receive an end of one end of shuttle valve 60, which will be described later. The other end of each side bypass passage 42 is opened at the outer peripheral surface of first plate 11, and is in communication with suction chamber 29.

Cylinders 50, which are formed in rib 14 of first plate 11, are coaxial to bypass hole 41 and are in communication with the side bypass passage 42. Control pressure passage 7 described before are coaxial with bypass hole 41, and the cylinders 50 are also in communication with these control pressure passage 7. Each cylinder 50 has small diameter portion 50a and large diameter portion 50b. Small diameter portions 50a directly continue to the ends of side bypass passage 42.

Shuttle valve 60 having a nearly T-shaped cross section is slidably disposed in each cylinder 50. Since cylinder 50 are coaxial with bypass hole 41, shuttle valves 60 are also coaxial with the bypass hole 41. An end of each shuttle valve 60 is movable into and away from the end 42a of side bypass passage 42. When the end of shuttle valve 60 moves into the end 42a of side bypass passage 42, bypass passage 40 is closed. When the end of shuttle valve 60 moves away from the end 42a of side bypass passage 42, bypass passage 40 is opened. Seal member 60 is attached around the rear end of each shuttle valve 60.

Spring 70 is disposed around each shuttle valve 60, and is located in large diameter portion 50b of cylinder 50. An end spring 50 is in contact with stepped portion 50c formed between small and large diameter portions 50a and 50b of cylinder 50, and the other end is in contact with the rear end of shuttle valve 60. Thereby, spring 70 biases shuttle valve 60 to move its end away from the end 42a of side bypass passage 42. Thus, spring 70 biases shuttle valve 60 to open bypass passage 40.

Referring also to Figures 6,7,8, the three-way electromagnetic valve 80 is disposed in the electromagnetic valve accommodating chamber 9 in cup-shaped casing 2. Three-way electromagnetic valve 80 has a first port 81, second port 82 and a third port 83. Cup-shaped 2 is provided at its one end with communication passage 90 having one end communicating with first port 81 and the other end communicating with one of control pressure passage 7. Communication passage 90, two control pressure passage 7 and communication passage 15 form control pressure passage 7 for communicating two cylinders 50 to first port 81. Cup-shaped casing 2 is also provided at its one end with an outlet pressure passage 91 communicating discharge chamber 17 to second port 82. Further, as can be seen from Figure 2, cup-shaped casing 2 is provided at its one end with passage 92 axially extending from the electromagnetic valve accommodating chamber 9. First plate 11 is provided with passage 93 having one end communicating with passage 92 and the other end communicating with side bypass passage 42. These passages 92 and 93 as well as side bypass passage 42 form a suction pressure passage communicating suction chamber 29 with third port 83.

As shown in Figures 8(a) and (b), when the three-way electromagnetic valve 80 is turned off, sealing surface A is opened and sealing surface B is closed, whereby an discharge pressure gas is introduced through outlet pressure passage 91 into second port 82. Discharge pressure gas introduced into the second port 82 flows over sealing surface A and is introduced through first port 81 into one of control pressure passage 7, and further the gas is introduced through communication passage 15 into the other control pressure passage 7. Thereby, the discharge pressure gas is introduced into the two cylinders 50, so that the discharge pressure is applied against the rear surface of shuttle valve 60 disposed in each cylinder 50. Assuming that the control pressure introduced into the cylinder 50 is Pc, the pressure of the gas being compressed in fluid pocket 23 located at a position allowing communicating with bypass hole 41

is Pm, the discharge pressure is Pd, the suction pressure is Ps and the spring force of spring 70 is F, force P caused by the difference between the forces applied to the opposite end surface of the shuttle valve 60 is expressed as follow.

$$P = Pc - (Pm + F)$$

Meanwhile, the members and portions described above are designed to establish a relationship of Pd > Pm + F. When the three-way electromagnetic valve 80 is turned off, a relationship of Pc = Pd is established, and thus a relationship of Pc - (Pm + F) > 0 is established. In the case of P > 0, there is generated a force biasing shuttle valve 60 toward bypass hole 41, so that side bypass passage 42 are closed and the compressor attains the maximum displacement driving state.

When three-way electromagnetic valve 80 is turned on in the maximum displacement driving state, sealing surface A is closed and sealing surface 8 is opened, as shown in Figures 9(a) and (b), so that the first and second ports 81 and 82 are isolated from each other, and thus control pressure passage 7 is isolated from discharge pressure passage 91. Meanwhile,first and third ports 81 and 83 are communicated with each other, and control pressure passage and suction pressure passage are communicated with each other. Thereby, the discharge pressure gas introduced into each cylinder 50 escapes through control passage 7, three-way electromagnetic valve 80 and suction pressure passage to suction chamber 29, so that the suction pressure is applied the rear surface of each shuttle valve 60. In this state, the relationship of the force applied to the opposite end surface of shuttle valve 60 can be expressed as P = Pc - (Pm + F), as described before, which can be rewritten as P = Pc - Pm - P, and can be further rewritten as P = (Pc - Pm) - F. Owing to the fact of Ps < Pm, a relationship of Ps - Pm < 0 is established. Further, owing to the fact of Pc = Ps, a relationship of Pc- Pm < 0 is established. In this case, all the minus (-) forces act to move shuttle valve 60 away from bypass hole 41. Therefore, the fact for moving shuttle valve 60 away from bypass hole 41 is formed of the force expressed by (Pc - Pm) in addition to spring force F, which is different from the prior art, so that the responsibility of each shuttle valve 60 is improved.

According to a variable displacement scroll compressor of the invention, shuttle valve 60, which is moving to open bypass hole 41, receives at its one end the pressure of the fluid which is being compressed in addition to the spring force which biases shuttle valve 60, so that shuttle valve 60 has the superior responsibility as compared with the prior art and thus the responsibility in the displacement controlling operation of the compressor is improved.

Further, according to the variable displacement scroll compressor of the invention, spring 70 biasing shuttle valve 60 is disposed in the cylinder without protruding into bypass hole 41, the pressure loss which is caused by the fluid resistance of spring 70 in the fluid gas in bypass hole 41 can be smaller than one of the prior art, so that the minimum displacement can be precisely obtained.

Claims

1. A variable displacement scroll type compressor including a housing having a fluid suction port and a fluid discharge port, a fixed scroll member having a first circular end plate and a first spiral element extending from one end of said first circular end plate, a discharge hole formed at a central portion of said first circular end plate, said fixed scroll member fixedly disposed in said housing, an orbiting scroll member having a second circular end plate and a second spiral element which extends from one end of said second circular end plate, a driving mechanism to effect the orbital motion of said orbiting scroll member, and a rotation-preventing mechanism for preventing the rotation of said orbiting scroll member during its orbital motion whereby the volume of the sealed-off fluid pockets change, a suction chamber formed between an outer peripheral surface of said fixed scroll member and said orbiting scroll member and an inner peripheral surface of said housing, and being communicated with said fluid suction port, a discharge chamber communicated with said discharge hole and said fluid discharge port, at least one bypass passage communicating at least one corresponding intermediately located fluid pocket with said suction chamber, at least one cylinder corresponding said at least one bypass passage formed within said at least one bypass passage, at least one valve member corresponding at least one said bypass passage having a first axial end and a second axial end slidably disposed within said corresponding at least one cylinder so as to close and open said at least one bypass passage, and an elastic member biasing said at least one corresponding valve member to urge said at least one valve member so as to close said at least one bypass passage, the improvement comprising:

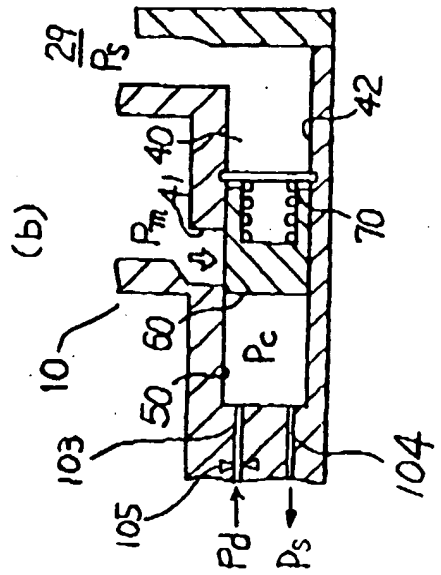
said at least one cylinder located so as to let said at least one valve member receive pressure in said at least one intermediately located sealed-off fluid pocket at said first axial end thereof, communication control means for selectively controlling a communication between said suction chamber and a cavity defined by said second axial end of said valve member and said at least one cylinder, and a communication between said discharge chamber and said cavity.

2. The scroll type compressor recited in claim 1 wherein said communication control means is an electromagnetic three-way valve.

3. The scroll type compressor recited in claim 1 wherein said at least one bypass passage is a pair of bypass passages corresponding a pair of the intermediately located sealed off fluid pockets.

4. The scroll type compressor recited in claim 3, said fixed scroll member further including a protection axially projecting from another end of said first circular end plate opposite to said first spiral element, said projection including an end surface facing to an inner bottom end surface of said housing, said pair of cylinders formed in said projection, a communication path linking said cavity of said each of cylinders, said communication path formed between said end surface of said protection and said inner bottom end surface of said housing.

5. The scroll type compressor recited in claim 4 wherein said communication path is a groove formed at the inner bottom end surface of said housing.



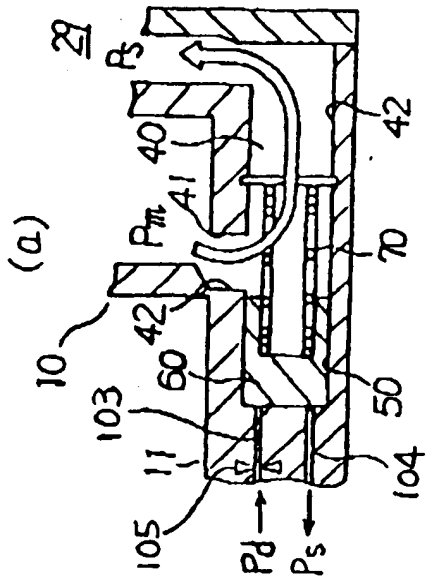


FIG. 1
(Prior art)

FIG.2

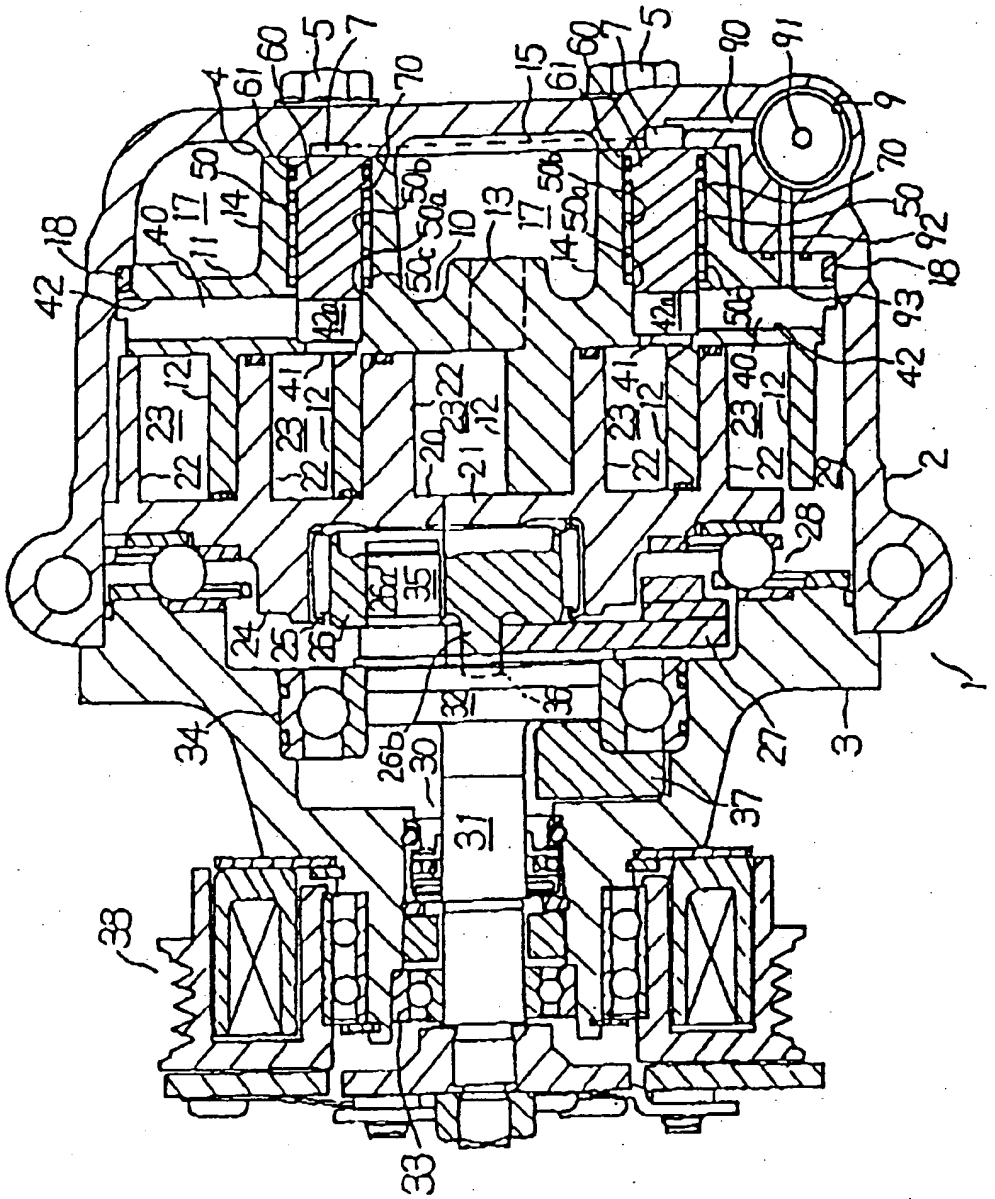

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FIG.3

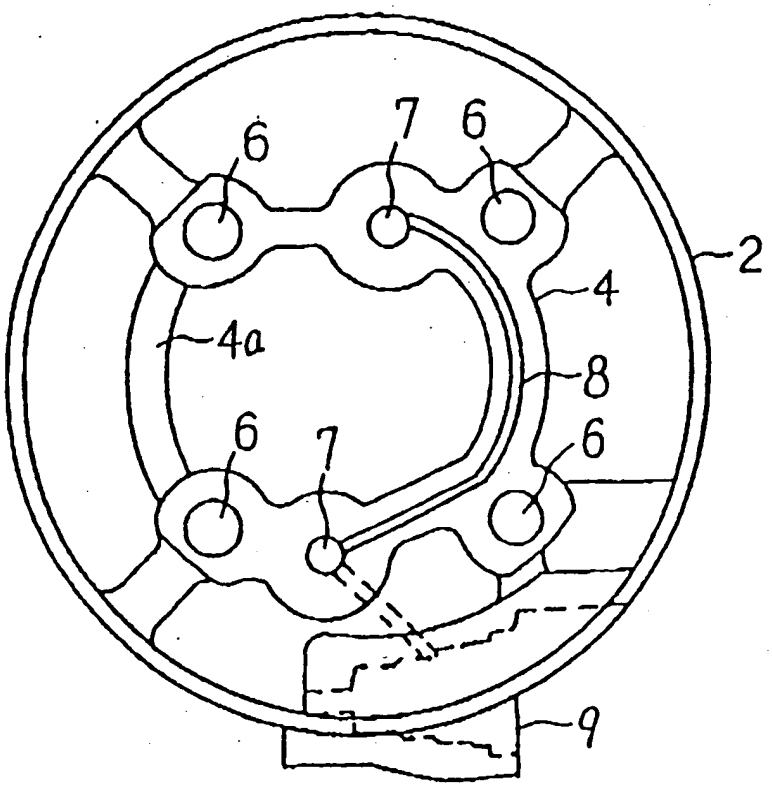

FIG.4

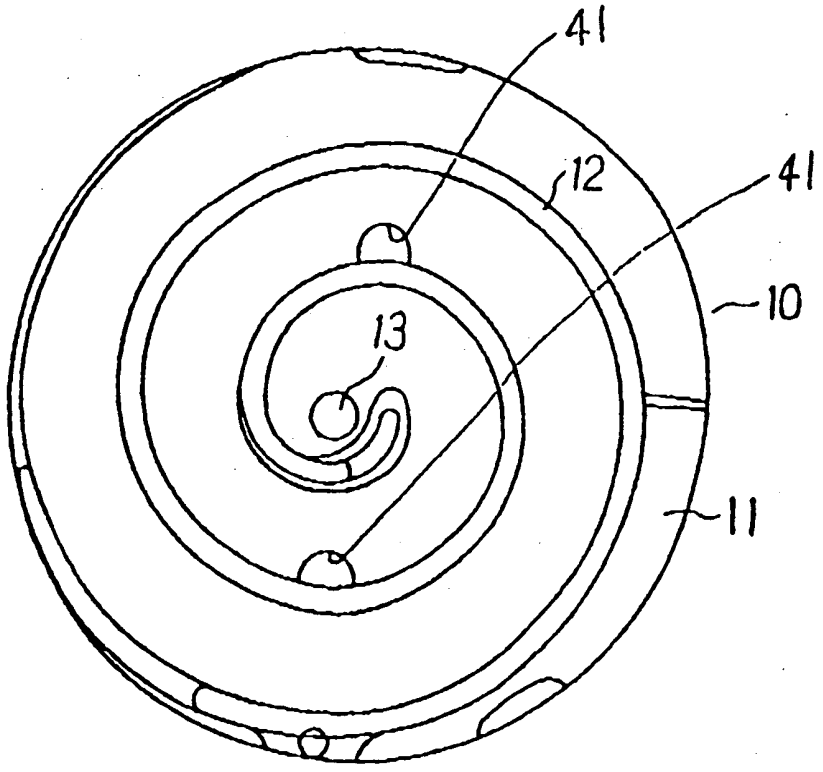

FIG. 5

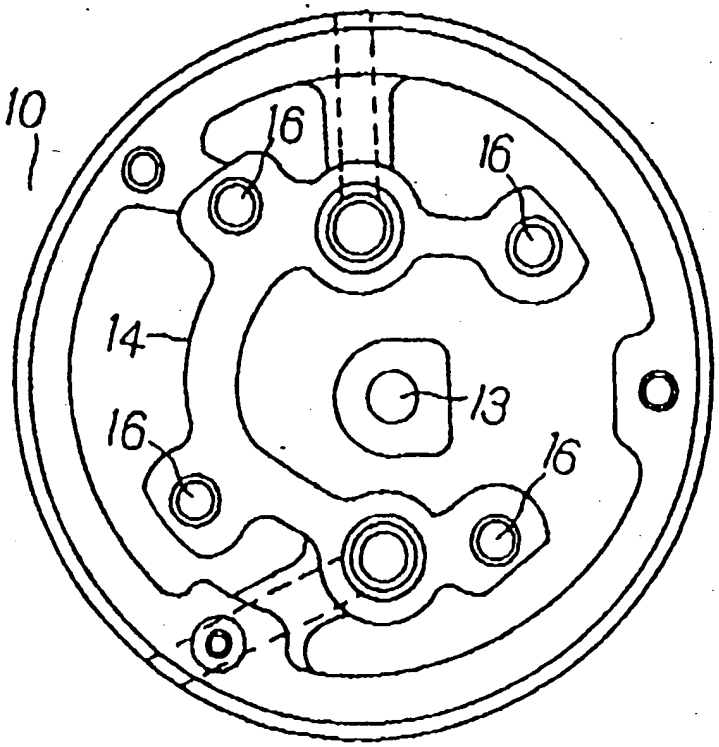

FIG. 6

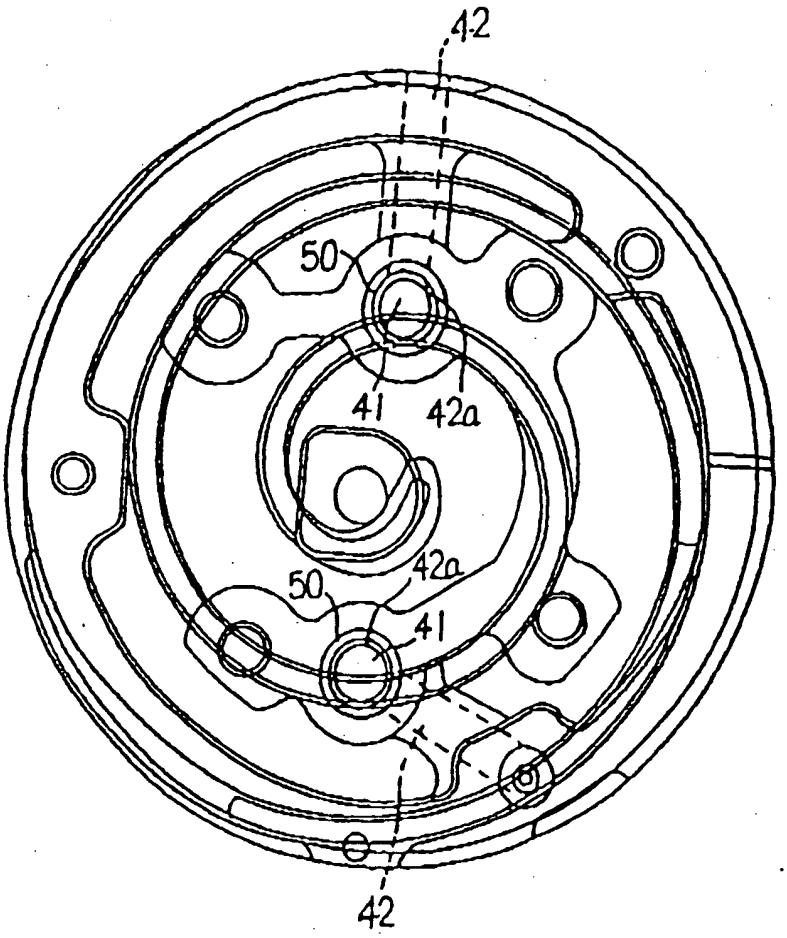

FIG. 7

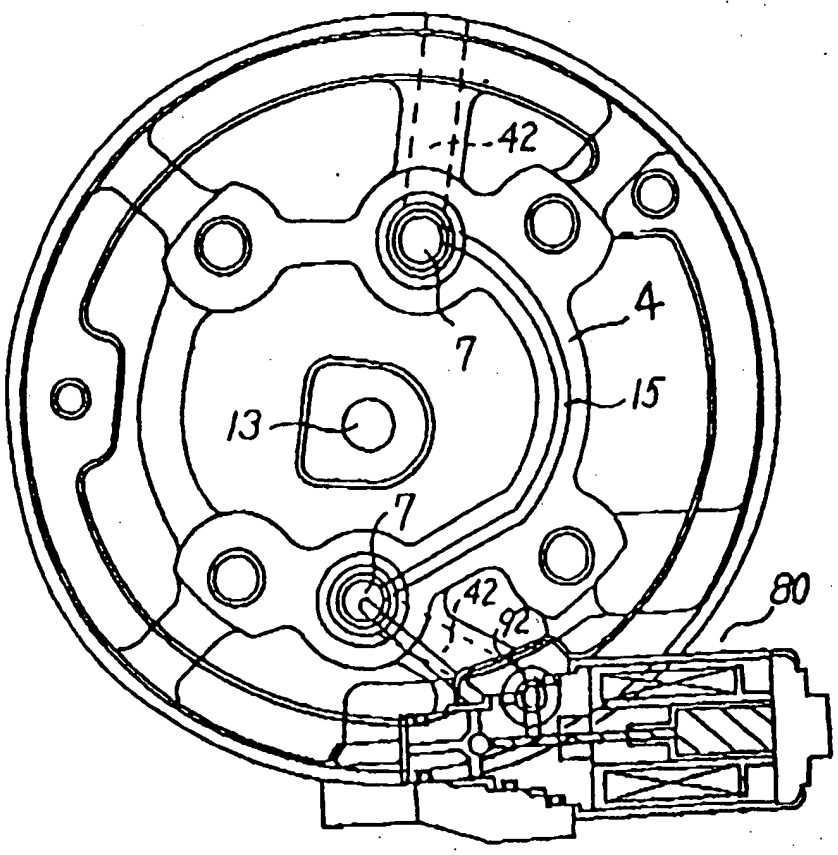

FIG. 8

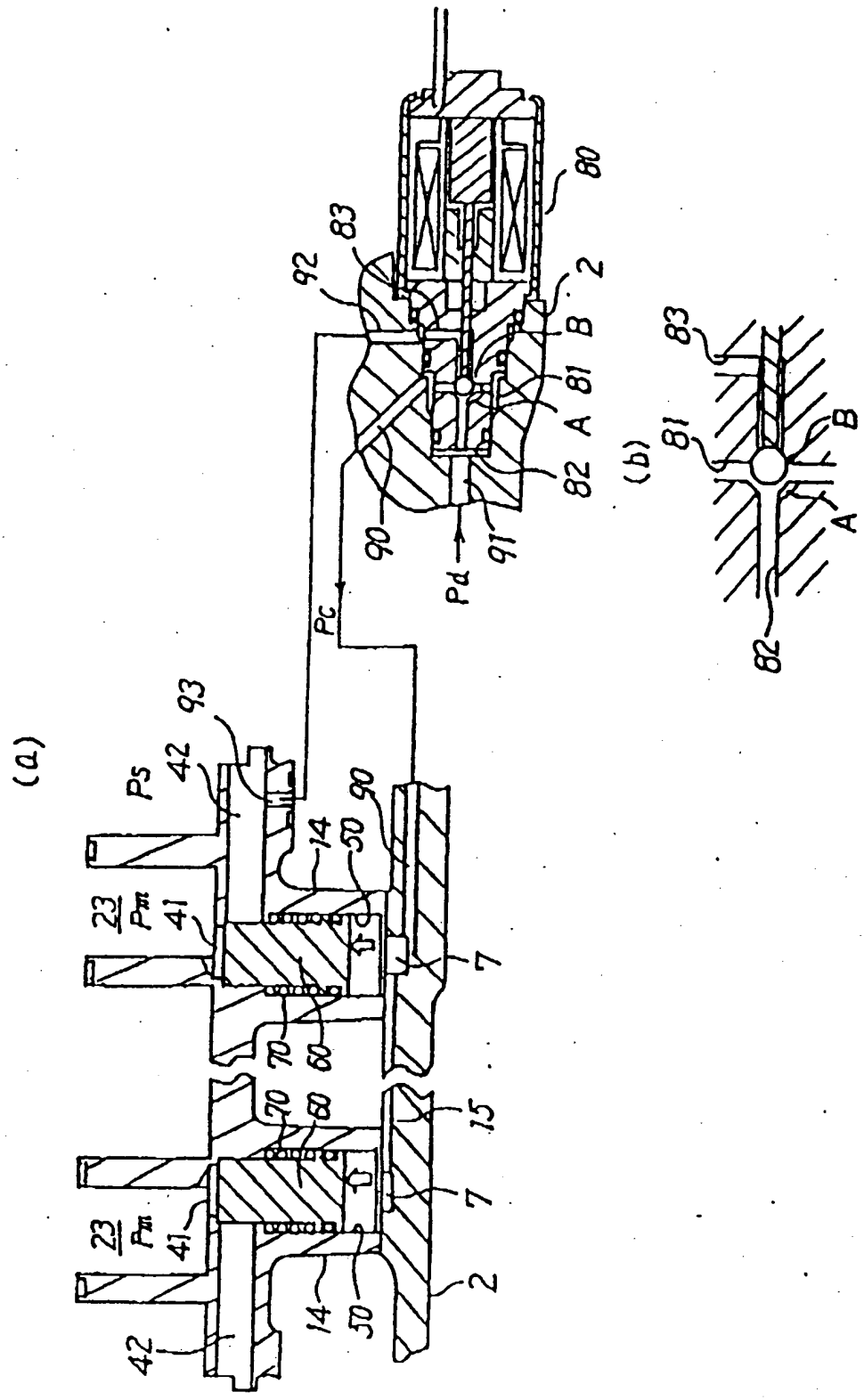
(a)
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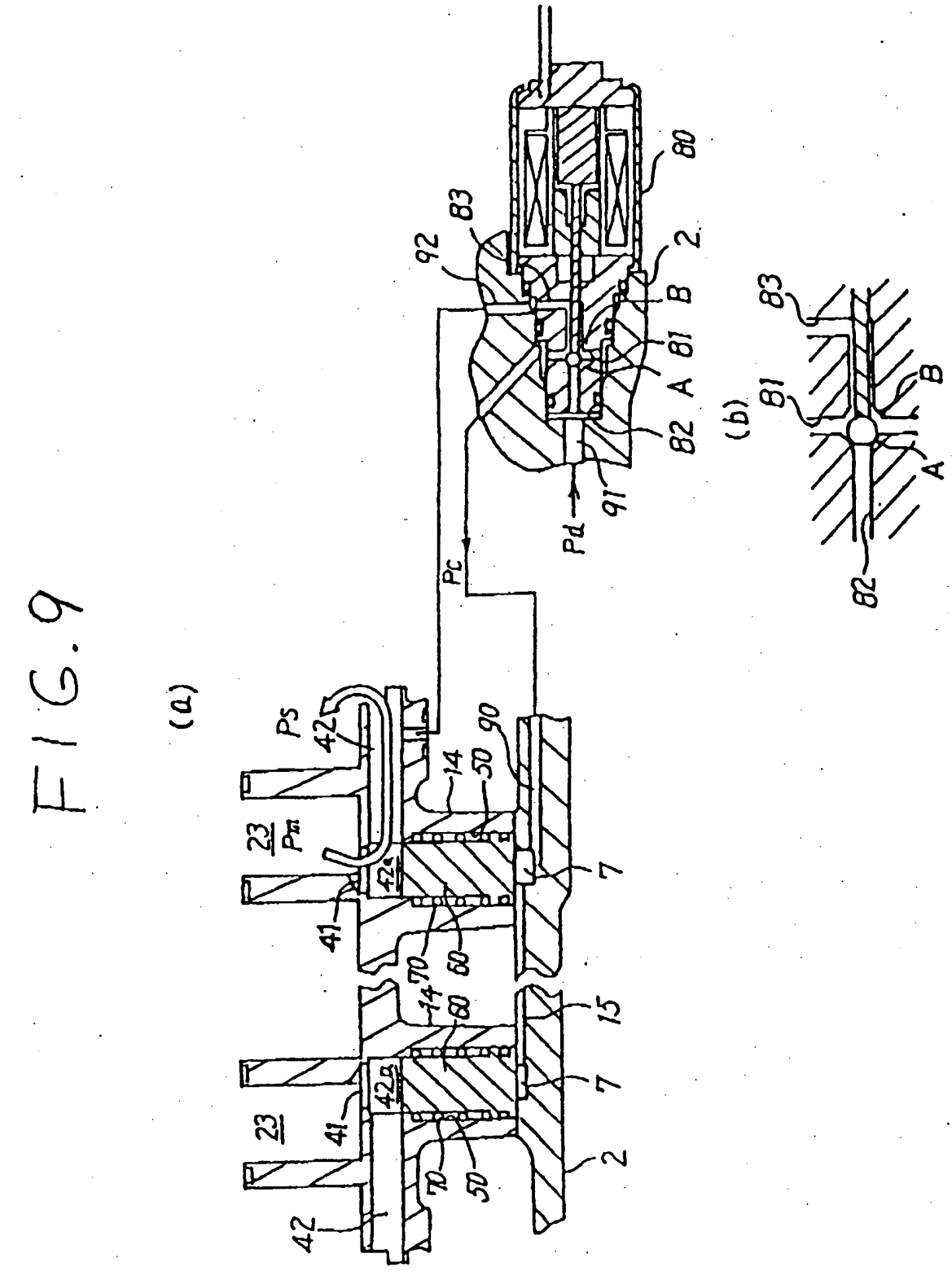
FIG. 9



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EUROPEAN SEARCH REPORT

Application Number
EP 93 30 1025

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
X	DE-A-3 739 978 (MITSUBISHI DENKI K.K.) * the whole document *	1-3	F04C29/10 F04C18/02
A	DE-A-3 804 418 (MITSUBISHI JUKOGYO K.K.) * the whole document *	1	
A	US-A-4 940 395 (YAMAMOTO ET AL.) * the whole document *	1	
A	US-A-5 059 098 (SUZUKI ET AL.) * the whole document *	1	
A	DE-A-3 142 744 (HITACHI LTD.)		

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

F04C

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	27 MAY 1993	DIMITROULAS P.

CATEGORY OF CITED DOCUMENTS

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